THE MEASUREMENT OF BLOOD PRESSURE BY REGISTERED NURSES

by

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A CLINICAL INVESTIGATION

Presented to

The University of Oregon School of Nursing
and the Graduate Council of the University of Oregon
Health Sciences Center
in partial fulfillment of the requirements for the degree of

MASTER OF NURSING

June, 1979

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This study was supported in part by the Department of Health, Education, and Welfare Professional Nurse Traineeship, Grant Number 5 A11 NU00250-02.

ACKNOWLEDGEMENTS

This researcher wishes to express sincere appreciation to Marie Berger for her encouragement and direction; to Barbara Gaines for her attention to detail; and to Dorothy Elhart for her consistent and timely counsel. Acknowledgement is also given to the Portland Veteran's Administration Hospital nursing staff for their assistance and especially to Arlene Strong for her warm understanding and continued friendship. Special recognition is given to Susie Svicarovich, Cliff Nutting, and the nursing students of Clackamas Community College for giving so freely of their time and for being available on short notice.

Personal gratitude is expressed to my brother, to my mother and father, and especially to my husband for their assistance, confidence, and reassurance throughout this process.

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CHAPTER I

INTRODUCTION

Introduction to the Problem

Indirect blood pressure measurement is a standard procedure in the physical examination of a client. Health care providers, especially nurses, perform thousands of blood pressure measurements each day. Blood pressure readings are utilized when making decisions about diagnosis, treatment, treatment evaluation, and prognosis. In addition acceptable blood pressure readings may be the criteria for obtaining life insurance or employment. With the heightened awareness of the disease, hypertension, millions of persons are having their blood pressures taken by nurses in hypertension screening clinics, as well as in institutions and offices.

When the proper procedure for obtaining an indirect blood pressure is followed, a reliable measurement is obtained which adds important, objective information to the health status picture of the client. The American Heart Association (AHA) has drawn up recommendations for determining blood pressure by sphygmomanometry; the most commonly used method for obtaining an indirect blood pressure (Kirkendall, Burton, Epstein, & Freis, 1967). While relatively accurate, the indirect method of determining blood pressure has shortcomings. The indirect method inherently has an error of $\pm$ 8 mm Hg for both systolic and diastolic pressures when compared with the direct method of intra-arterial measurements (Kirkendall, et al., 1967). This error range is acceptable when compared to the ease of obtaining a reading. The indirect method is non-invasive, takes a short period of time to perform, is relatively painless and non-disturbing to the client, and uses only two instruments,

a sphygmomanometer and a stethoscope, both of which are relatively inexpensive, and with reasonable care, can be used for a long period of time.

The problem in measuring blood pressure by the indirect method of using a sphygmomanometer and a stethoscope, then, is not in the lack of an accepted procedure to follow, but in how uniformly the procedure is followed by those who measure blood pressure. Variations in the client's arterial pressure, instrument errors and observer errors contribute to the variability of the blood pressure measurement when proper procedures are not followed (Page & Sidd, 1972; George, Lewis, & Petrie, 1975). Other studies have also demonstrated that there is continued confusion regarding the interpretation of the Korotkoff sounds especially for diastolic pressure (Burton, 1967; King, 1969; Page & Sidd, 1972; Steinfeld, Alexander, & Cohen, 1974).

It has been shown by Mitchell and Van Meter (1971) that at least some nurses are not aware of the recommendations made by the AHA or if they are aware, do not adhere to them in practice. By comparing blood pressure values obtained by the investigators using the AHA recommendations to blood pressure values obtained by personnel who were unaware of being observed, 37 to 46 per cent of the blood pressure values could not be reproduced within $\pm$ 10 mm Hg, and 21 to 27 per cent could not be reproduced within $\pm$ 15 mm Hg. Other studies have investigated observer factors in measuring blood pressure, (Wilcox, 1961) and the capability of observers to reproduce blood pressure measurements using standardized procedures (Bender, 1970; Glor, 1966; Glor, Sullivan, & Estes, 1970; Glor, Sullivan, & Glor, 1966).

The measurement of blood pressure is taught to each nursing student during the educational process. However, since there are a variety of references which may differ in the procedure of blood pressure measurement, nursing students may not be taught the AHA standardized procedure. In addition, the nurse, once in practice, may not follow the AHA recommendations for blood pressure measurement. Accuracy will depend to a large extent on the nurse following a standardized procedure which has been shown to cause the fewest possibilities for error. Burch and DePasquale (1962) declare, "Remember--No data is better than wrong data." (p. 121), and Page (1968) echoes those words in an editorial by saying, "Far better no measurement at all than an inaccurate one. I mean it!" (p. 74).

Statement of the Problem

In the last twenty years, much consideration has been given to the variability of blood pressure and to the variability of blood pressure measurements. Research studies have pointed out wide variations in blood pressure readings. Differences resulting from the observer such as the interpretation of the Korotkoff sounds, prejudice for selecting certain numbers, and reading a moving column have been studied. Differences as a result of the instrument such as lack of calibration and dirty instruments have also been studied. The adherence to a standardized procedure has received less attention than other aspects of blood pressure measurement. The problems addressed in this paper are: (1) How many errors are made by registered nurses in the technique of blood pressure measurement? (2) How effective is a review of or an introduction to the technique prescribed by the AHA in decreasing errors?

Review of the Literature

The literature review includes three categories pertinent to the study of blood pressure measurement. A review of the physiology of blood pressure measurement is important as the basis of understanding the hemodynamic factors that blood pressure measurement considers. An historical review of the research of both blood pressure and its measurement gives background to present methods of measurement and to the knowledge of blood pressure. The literature on the variability of blood pressure measurements is also reviewed to demonstrate the many possibilities of error and the need for standardization of procedures in order to obtain a reliable, objective measurement.

Physiology of Blood Pressure Measurement

Systemic arterial blood pressure represents a force which is the result of cardiac output and peripheral vascular resistance (Kirkendall, et al., 1967). The cardiac output is determined by the force of the pump (left ventricle) as it expells an amount of blood from its chamber (stroke volume) and by the number of contractions of the left ventricle for a given amount of time (heart rate). The formula is:

Cardiac Output = Heart Rate X Stroke Volume

(Liters/min.) (Beats/min.) (Liters/Beat)

(Vander, Sherman, & Luciano, 1975, p. 241).

Peripheral vascular resistance is determined by the nature of the fluid and the geometry of the vessels (Vander, et al., 1975). Blood has a relatively constant viscosity and, therefore, contributes only minor changes to resistance. The geometry of the vessels, then, is the more important factor of the two in determining resistance. The length and

radius of the vessels determine the amount of resistance. In the arterial circulation, the aorta, the arteries, and the capillaries are the vessels. Since the length of the arterial system remains unchanged, the radius of the aorta, arteries, and capillaries contribute the major resistance factor. The aorta and arteries convert the pulsated flow of blood to a continuous peripheral flow. These arteries are characterized by high flow velocity and low resistance (Hurst, 1974). The arterioles and capillaries, on the other hand, are characterized by low flow velocity and high resistance (Hurst, 1974).

As the blood is pumped from the left ventricle into the aorta and arteries, there are changes in pressure along the route. The pressure which the left ventricle exerts on the arterial system is called systolic pressure, and is determined by the volume and velocity of ventricular ejection, the peripheral arteriolar resistance, the distensibility of the arterial wall, the viscosity of the blood, and the end-diastolic volume in the arterial system (Hurst, 1974). The diastolic pressure is the minimum pressure in the arterial system just before ventricular ejection. This pressure is determined by the viscosity of the blood, the arterial distensibility, the peripheral resistance, and the cardiac cycle length (Hurst, 1974).

These two pressures, systolic and diastolic, can be measured either directly by arterial puncture or indirectly by external instruments, and are important indicators of the client's cardiovascular status.

History of Blood Pressure Measurement

Blood pressure was first measured by Hales in 1733 when his curiosity led him to insert a copper pipe into an artery of a mare. A glass

tube was attached to the copper pipe, and Hales observed that the blood rose in the glass tube to a height of 8 ft. 3 in. (as cited in Skidmore and Marshall, 1976 and in Burch and DePasquale, 1962). This direct method of measuring blood pressure was the beginning of experimentation which has led to the present day knowledge and instrumentation of blood pressure measurement.

Indirect blood pressure measurement was not devised until about 1834 when Hérrison used an apparatus which could be placed directly over an artery (Burch & DePasquale, 1962). This instrument consisted of a metal sphere attached to a capillary tube filled with mercury. The metal sphere was covered with a membrane, which, when placed over an artery, transmitted the oscillations to the mercury column. The variations of the mercury column were considered to be variations in the arterial pressure.

Researchers continued to develop instruments to measure blood pressure indirectly, and these instruments came to be known as "sphygmomanometers", from the Greek words, "sphygmos", meaning pulse, and "metron", meaning measure. The principle of counterpressure was used, and from about 1850 to 1900 several scientists including Vierordt, Behier, Foster, Landois, Marey, Philadelphien, and Von Basch (Burch & DePasquale, 1962) developed instruments which used counterpressure to occlude arterial blood flow, and therefore, measure blood pressure. These instruments were designed for occluding blood flow in fingers, in the entire forearm, or directly over an artery, such as the radial artery. However, clinical applications of these instruments were not practical because the instruments were large and cumbersome to transport,

mechanically difficult to apply, and often inaccurate.

In the late 1890's Riva-Rocci in Italy and Hill and Barnard in England almost simultaneously introduced the use of the air-inflated, arm-occluding cuff (Geddes, 1970). The air-inflated cuff was filled to a pressure at which the radial pulse disappeared. As the cuff pressure was decreased, the pressure was again measured when the radial pulse reappeared. The mean of these two pressure readings was recorded as the systolic pressure. This instrument was the forerunner of our present sphygmomanometer, since Riva-Rocci used a mercury manometer and Hill and Barnard used an aneroid manometer.

The first cuffs used by Riva-Rocci and Hill and Barnard were too narrow for an accurate blood pressure measurement and required a higher pressure than actual systolic pressure to occlude the artery. Von Recklinghausen in 1901 demonstrated that a wider cuff gave more accurate occluding pressures in the adult arm (Geddes, 1970). The cuff width used by Von Recklinghausen was 10 to 12 cm wide, while those of Riva-Rocci and Hill and Barnard were 5 cm and 8 cm wide, respectively (Burch & DePasquale, 1962; Geddes, 1970).

By the early 1900's there were a variety of instruments for measuring blood pressure. Erlanger in 1904 reviewed the many instruments and concluded that since new instruments were being devised, there must be dissatisfaction with the already existing instruments (Burch & DePasquale, 1962). Burch and DePasquale (1962) point out, however, that during this time, it was the lack of knowledge in interpreting the data provided by the instruments that was the problem, not the instruments, per se. Maximal pressure, mean pressure, and minimal pressure were not clearly understood.

Maximal pressure was determined by Vierordt's principle, in which the pressure required to obliterate the pulse wave distal to the point of compression was considered the maximal or systolic pressure. Von Recklinghausen, however, believed that the maximum pressure was determined not by the absence of the pulse wave but by the beginning of the pulse wave after the artery had been occluded. Von Recklinghausen and others, then, advocated the determination of maximal pressure by increasing the pressure until the pulse wave was absent, then slowly decreasing the pressure in the cuff until the pulse wave could again be palpated, and recording that pressure from the manometer as the maximal pressure (Burch & DePasquale, 1962).

The minimal or diastolic pressure was determined according to Marey's principle. Marey believed that as the counterpressure of the sphygmomanometer was reduced, the point at which the greatest force of the pulsations of the artery could be palpated was when the counterpressure and the intra-arterial pressure were equal. The artery at the time of the two equal pressures was free of tension and fluctuated without restriction. Others disagreed with Marey and believed that the greatest force of the pulsations palpated was the mean pressure (Burch & DePasquale, 1962).

Erlanger, after constructing an instrument which determined minimal and maximal pressures with a high degree of accuracy, conducted studies which greatly contributed to more understanding in regard to this phase of blood pressure measurement. Erlanger concluded that maximal blood pressure corresponded to the point when there was an abrupt increase in the amplitude of the oscillations of the arterial

wall. Minimal blood pressure, according to Erlanger, was the point at which the arterial wall oscillated the most as the counterpressure was decreased (Burch & DePasquale, 1962).

In 1905 Korotkoff described sounds which could be heard over an artery below a compression cuff. The auscultatory method of determining blood pressure instead of the palpatory method could now be utilized, at least in most cases. The Korotkoff sounds, as they are still known, were first divided into three and then five phases. The first sound is universally accepted as the maximal or systolic pressure, but there is some controversy over whether the fourth or fifth phase of the sounds should be recorded as the minimal or diastolic pressure (Burch & DePasquale, 1962; Geddes, 1970).

Since the turn of the century researchers have continued to modify the earlier instruments by making them smaller, easily portable, more reliable, and more durable. The indirect methods for accurately measuring blood pressure also continue to be studied and refined as new knowledge is generated. New technology has added instruments which are more automated and utilize electronic signals instead of auscultated sounds, but the basic sphygmomanometer continues to be widely used.

Variability of Blood Pressure Measurements

When measuring blood pressure by sphygmomanometry, many variables must be considered. Rose, Holland, and Crowley (1964) have schematically shown the sources of variability in blood pressure measurements (See Figure 1). The AHA has drawn up recommendations for determining blood pressure by sphygmomanometry. These recommendations were first established in 1939 by a joint effort of the AHA and the Cardiac Society

of Great Britain and Ireland. In 1951 the recommendations were revised, and the goal as stated was to aid "examiners to avoid pitfalls and, as far as possible, to establish greater reliability and uniformity in measuring systolic and diastolic pressures" (Bordley, Conner, Hamilton, Kerr, & Wiggers, 1951, p. 503). The 1967 recommendations are the current ones. These recommendations have been published by the AHA in a booklet titled Recommendations for Human Blood Pressure Determination by Sphygmomanometers, and have appeared in a medical journal, Circulation (1967).

The recommendations by the AHA deal primarily with the known factors of true variation in arterial pressure and with measurement errors; those resulting from instrument and observer measurement errors as outlined by Rose, et al., (1964) in Figure 1. A review of these three variables follows.

True Variation.

Human blood pressure is constantly changing depending upon inherent factors. Some factors may not be controlled but should be considered when measuring blood pressure. Age, sex, body weight, race, and heredity (Burch & DePasquale, 1962) all have an effect on blood pressure. Not unlike temperature, blood pressure varies during a 24 hour period. Stephens (1966) notes that results of studies indicate that blood pressure is lowest during the night around 3 a.m. and highest during the evening around 6 p.m. Sleep produces a profound variation of as much as 20 to 30 mm Hg in blood pressure from daytime readings, with the greater variation being in the systolic rather than in the diastolic pressure (Page & Sidd, 1972). Other biological factors

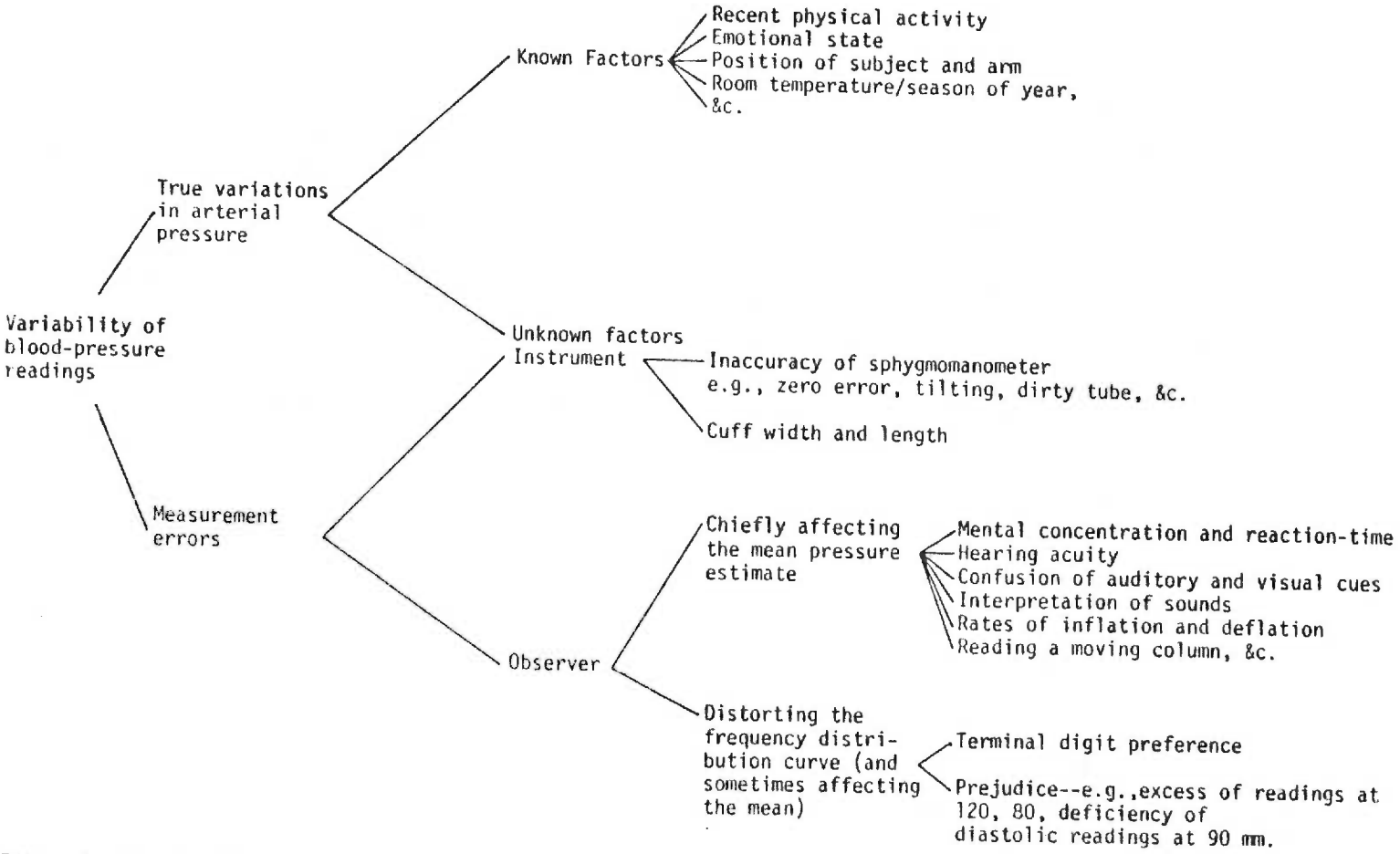

Figure 1. A schematic representation of some sources of variation in measuring blood-pressure.

(Rose, et al., 1964, p. 297)

which may produce variability in blood pressure include anxiety, emotional turmoil, tobacco, meals, bladder distention, climate variation, exertion, and pain (Burch & DePasquale, 1962; Kirkendall, et al., 1967). Visits to a physician have been observed to increase the blood pressure, (Page & Sidd, 1972) and may be an example of a change as a result of anxiety. Respiration, which results in changes in intrathoracic pressures, also causes moment-to-moment changes in blood pressure, (Stephens, 1966) as do postural changes and arrhythmias. The height of the arm in relation to the heart level when blood pressure measurements are taken also produced variations (Mitchell, Parlin, & Blackburn, 1974).

The AHA recommends that the patient's biological status be considered in an attempt to control as many variables as possible. The suggested standard conditions for indirect measurement include the position of the patient and the condition under which the blood pressure is measured.

> Position: The patient should be comfortably seated with the arm slightly flexed and with the whole forearm supported at heart level on a smooth surface. There should be no postural changes for five minutes before recording.
>
> Conditions: Biological factors which alter blood pressure should be recognized and noted. When possible all such stimuli should be controlled or avoided. The patient should be in a quiet room at a comfortable temperature, with his arm unconstricted by clothing or other material. He should avoid exertion, exposure to

cold, and eating or smoking for a half hour before the measurement (Kirkendall, et al., 1967, p. 982).

Measurement Errors.

Another source of variability in blood pressure measurements are those measurement errors which result from the instrument. It is generally not known how often errors are made as a result of the maintenance of the instruments, but it would seem certain that instruments should be cleaned, checked, and calibrated at regular intervals. Corns (1967) gives maintenance recommendations for checking the function of the inflation system, the mercury manometers, and the aneroid manometers. She also outlines what can go wrong with the parts of sphygmomanometers and how to make repairs. Manufacturers give maintenance instructions with their specific instruments, as well.

The AHA recommends frequent checks of the inflating system, the exhaust valve, and the tubing for leaks and for competent, smooth functioning input and exhaust. Recommendations are also given for checking the amount and level of mercury in the mercury manometers, for calibrating both mercury and aneroid manometers, and for cleanliness of the instrument.

The other factors which may produce errors of blood pressure measurement are the size of the inflatable bag and the cuff and the material of which the cuff is made. The AHA recommends that the cuff material be made of "nondistensible material" (Kirkendall, et al., 1967, p. 980). There are no specific recommendations by the AHA in regard to cuff width, except that the inflatable bag should be 20 per cent wider than

the patient's arm diameter and should be long enough to half encircle the arm if the bag is placed directly over the artery to be compressed.

It is safe to say that all sphygmomanometers meet the recommendation of the type of material to be used for the cuff and that the cuffs will be of sufficient length to be placed on the arm correctly, whether they are made as a long-ended wrapping style or as a special closure style such as the velcro closures. The issue which has been subjected to testing is the width and the length of the inflatable bag.

Von Recklinghausen was the first to observe that narrow inflatable bags gave too high blood pressure readings. Since that time investigations have continued in an attempt to describe the relationship between bag length and width and adequate compression of the artery.

The standard bag size for compression of the arms of adults is 12 cm wide and 23 cm long (Simpson, Jamieson, Dickhaus, & Grover, 1965). There continues to be some question as to whether this size is adequate for optimum compression. There are data to support the position advocating a longer bag than that recommended by the AHA in order to reduce the possibility of error. King (1969), as a result of his own experiments using a bag which encircles the limb (King, 1966), has concluded that the AHA should change their recommendation of cuff length. Steinfeld, Alexander, and Cohen (1974) also concluded that "a completely encircling pneumatic bladder is preferable to any abbreviated version," and "that...a short inner bladder and an outer sleeve of so-called stiff fabric seems to be less of a compromise than an open invitation to error" (p. 107).

Karvonen, Telivuo, and Jarvinen (1964) measured the blood pressures of fifty-three unselected surgical patients by using two different sized bags. One bag was the standard size of 12 cm wide and 23 cm long, and the second bag was the size recommended by the World Health Organization, 14 cm wide and 40 cm long. The values obtained using these two different bag sizes were compared to intra-arterial pressure measures. The large bag yielded systolic pressures which were lower and diastolic pressures which were higher than the intra-arterial pressures. With the smaller bag, the errors depended on the position of the bag on the arm. When the smaller bag was applied over the biceps and then over the triceps, both systolic pressures and diastolic pressures were higher than intra-arterial pressures. With the larger bag the random error was significantly smaller than with the smaller bag in either position.

A similar study utilized four different bag sizes (Simpson, et al., 1965). The pressure measurements obtained with the different bag sizes, 12 cm by 23 cm, 12 cm by 35 cm, 14 cm by 23 cm, and 14 cm by 35 cm, were compared with intra-arterial pressure measurements. Results of this study confirm that either a widening or a lengthening of the standard bag size produces a better correlation with the intra-arterial pressure.

A further source of variability in blood pressure measurements is those measurement errors which are the result of the observer and the technique. There are numerous possibilities for variation as a result of observer error. Some of the aspects of the recommended technique, which are subject to observer error, are mental concentration and reaction time, hearing acuity and vision, confusion of auditory and visual

cues, interpretation of the Korotkoff sounds, rates of inflation and deflation, and reading a moving column (Rose, et al., 1964).

Wilcox (1961) developed an interesting method in order to determine the magnitude of the variability among nurses measuring blood pressure. Wilcox used a sound motion picture which showed mercury manometers with the mercury being lowered. The Korotkoff sounds were recorded on the sound track. The observers were registered nurses. The results showed a wide inter-observer variation. The standard deviation for systolic pressures ranged from 4 to 16 mm Hg, while the standard deviation for diastolic pressures (both phase four and phase five) ranged from 2 to 45 mm Hg. Physicians were also tested using Wilcox's sound motion picture, (Rose, et al., 1964) and the results were similar to those for registered nurses.

A large survey study was carried out in Norway with nineteen nurses measuring blood pressures on about 70,000 persons in 4 1/2 months (Eilertsen & Humerfelt, 1968). One of the purposes of the research was to study observer variation, and the researchers concluded that even with carefully selected and specially trained observers, the variation in blood pressure readings may be substantial.

The nurses were thoroughly instructed in basic information about the testing procedures for measuring blood pressure in a two week training period. Detailed instructions were given to each nurse, and practical examinations were given under supervision to ensure that each nurse followed instructions and that there were no misunderstandings about the procedure. The subjects were participants in a mass radio-

graphy screening of the chest in a city of Norway and ranged in age from 15 to 100 years.

Total results of the blood pressure readings were studied for each observer. A systolic reading and both phase four and phase five diastolic readings were separately analyzed. The mean value of the systolic pressure readings for each observer was found to be as much as 5 to 11 mm Hg different from the group mean. Some of the observers differed as much as 8 to 9 mm Hg from the group mean in the two diastolic pressure readings.

In a 10 per cent random sample of the study population, two blood pressure instruments were used. One instrument was a conventional sphygmomanometer, and the second was the London School of Hygiene sphygmomanometer. The London School of Hygiene instrument consists of three separate mercury manometers, with keys which, when depressed, stop the fall of the mercury in the manometer. This instrument also has different calibrations than a conventional sphygomomanometer. Several variables in the procedure of measuring blood pressure are controlled by the London School of Hygiene instrument, so that in this study comparisons could be made between readings taken by each observer with the conventional sphygmomanometer and the London School of Hygiene instrument. Terminal digit preference (where an observer shows a prejudice for selecting a certain digit over other digits) in the total group was studied. With the conventional sphygmomanometer a slight preference for the digit, 0, was shown in 25 per cent of the readings. With the London School of Hygiene instrument the digit preference was much less, but the digit, 0, still was shown to be preferred over other digits in 14 per cent of the readings. It should be pointed out that

with the conventional sphygmomanometer, the digits used for reading blood pressures are the even digits, 0, 2, 4, 6, and 8. The digits on the London School of Hygiene instrument include all digits, 0 through 9. It was shown that the uneven digits were slightly underrepresented.

Mitchell and Van Meter (1971) observed nursing personnel recording blood pressures on clients and then, using the recommendations of the AHA as the standard, attempted to reproduce the blood pressure readings. Registered nurses, licensed practical nurses, and nursing assistants were included in the study. It was found that 37 to 46 per cent of the systolic and the two phases of the diastolic pressures could not be reproduced within $\pm$ 10 mm Hg, and that 21 to 27 per cent could not be reproduced within $\pm$ 15 mm Hg. It was also found that the mean differences of all three phases were greater for registered nurses than for licensed practical nurses or for nursing assistants.

Strictly controlled studies undertaken at the Walter Reed Army Institute of Research, Department of Nursing (Gunn, Sullivan, & Glor, 1966) showed procedural differences but no observer differences in blood pressure measurements. Since only two observers were used, Glor (1966) expanded the study to see if blood pressure measurements were reproducible using multiple observers when a standard procedure was employed.

Using a total of fifty-four observers, Glor selected registered nurses and nonprofessional nursing personnel as her subjects, and found no significant observer differences between registered nurses and nonprofessional nursing personnel. Glor, Sullivan, and Estes (1970) then replicated the previous study by Glor, and results again showed no observer differences for systolic or diastolic pressure measurements.

Inter-observer comparisons have also been reported by Bender (1970). After a training session for registered nurses, in which standard procedures were taught, it was found that blood pressure readings differed only by 2 to 3 mm Hg, even when patients were transferred from one clinic to another.

Summary

Systemic arterial blood pressure is the result of the cardiac output and peripheral vascular resistance. The systolic pressure is the pressure which the left ventricle exerts on the arterial system while the diastolic is the minimum pressure in the arterial system, just previous to ventricular ejection. These two pressures may be measured clinically by the direct method, arterial puncture, or by the indirect method, sphygmomanometry.

The arterial blood pressure was first measured directly in 1733 by arterial puncture. The first indirect measurement was not until 1834. As study and research developed instruments for measuring blood pressure, more was learned. The principle of using counterpressure to occlude an artery was developed.

The early instruments were well suited for laboratory work but were too large and difficult to transport. Eventually Riva-Rocci and Hill and Barnard introduced air-inflated arm-occluding cuffs, one with a mercury manometer and one with an aneroid manometer. These sphygmomanometers are the forerunners of the modern ones. With the explanation by Korotkoff of the sounds heard over an artery which had been occluded, came the auscultatory method of measuring blood pressure.

The earlier instruments have been modified so that they are now portable, relatively reliable, and durable. Much has been learned in regard to the proper technique for measuring blood pressure as well as about the physiological changes which occur in blood pressure measurement. The AHA has drawn up recommendations which consider both technique and physiological condition. Such inherent factors as age, sex, race, and heredity have an effect on blood pressure. Blood pressure is cyclic, with the lowest point in the early morning and the highest point in the evening. Certain other factors such as anxiety, tobacco, meals, and exercise change blood pressure readings from one moment to the next. These variables must be controlled as closely as possible when measuring blood pressure.

Instruments may also be a source of variability. Dirty instruments may give sporadic inaccurate readings while poorly calibrated instruments may give consistent inaccurate readings. The size of the inflatable bag and of the cuff for the size of the extremity has been studied (Karvonen, et al., 1964; Simpson, et al., 1965). While the standard bag is 12 cm wide and 23 cm long, there remains a question as to whether this size should be standard.

The observer factor is another source of variability when measuring blood pressure. Such aspects of measuring as mental concentration, reaction time, hearing acuity, vision, confusion of auditory and visual cues, interpretation of the Korotkoff sounds, inflation and deflation rates, and reading a moving column all may produce errors in the readings. Some (Bender, 1970; Glor, 1966; Glor, et al., 1970; Gunn, et al., 1966) have found no significant difference in blood pressure readings taken by nurses when a standardized procedure was taught

and/or followed. Differences have been shown, however, in inter-observer readings even when specific procedures were taught (Eilertsen & Humerfelt, 1968).

Blood pressure measurements taken by nurses and nursing assistants while on the job could only be partially reproduced within a ± 10 mm Hg range (Mitchell & Van Meter, 1971). Nurses and physicians with no specific preparation showed a wide variation in readings when tested with a sound motion picture (Rose, et al., 1964; Wilcox, 1961).

Statement of the Purpose of the Study

Blood pressure measurement is a common procedure in the practice of nursing. The blood pressure is subject to moment-to-moment changes as a result of regulatory factors, such as sympathetic and parasympathetic nerves and hormones, and environmental factors, such as temperature and exercise. The instruments and techniques for measuring blood pressure provide ample opportunity for errors. Measurements can be less variable when standards are followed. However the question remains, do nurses follow these standards in daily practice? Are the measurements of blood pressure entered on the client's record the most accurate representation of the vital sign of blood pressure?

The purpose of this study is to determine to what extent professional registered nurses follow the AHA recommendations in their practice for measuring blood pressure, and to determine if a review of or an introduction to the AHA recommendations changes their practice for measuring blood pressure. The nurses' practices for measuring blood pressure will be compared to the standards set up by the AHA. Experimental and control groups will be utilized.

Operational Definitions

Number of Errors: The number of incorrect procedural steps performed by the professional registered nurse when measuring blood pressure as the AHA recommends.

Demonstration Teaching: The method of teaching professional registered nurses the AHA recommendations through demonstration and individual explanation.

Booklet Teaching: The method of teaching professional registered nurses the AHA recommendations by giving each the booklet , Recommendations for Human Blood Pressure Determination by Sphygmomanometers, and asking that the booklet be read.

Hypotheses

1. There will be a significant difference in the number of errors in blood pressure measurement made by the Control Group when compared to the demonstration teaching Group B.

2. There will be a significant difference in the number of errors in blood pressure measurement made by the Control Group when compared to the booklet teaching Group C.

CHAPTER II

METHODOLOGY

Design

This research was an experimental study utilizing a post-test control group design. The study population consisted of forty-five professional registered nurses who were employed by a Veteran's Administration Hospital. The subjects were randomly chosen from 196 registered nurses and then randomly assigned to one of three groups. A control group was compared to two different treatment groups.

The post-test control group design controls for the following extraneous variables: selection, statistical regression, maturation, history, testing, experimental mortality, instrumentation (Campbell & Stanley, 1970). All subjects were chosen randomly and assigned to one of the three groups randomly, thus controlling for selection and statistical regression which might otherwise produce confounding results. Since there was only one time of measurement and only one test for each subject, the extraneous variables of maturation, history, testing, and experimental mortality, as sources of invalidity, were not confounding. The two observers remained the same throughout the study and, after specific verbal and written instructions were given, a pilot study was completed. An inter-rater reliability calculation of 85 per cent further verified the reliability between observers. The post-test control group design, then, controlled all of the confounding variables as discussed in Campbell and Stanley (1970, p. 5), and internal validity was not jeopardized.

The external validity of the post-test control group design is limited. By using only post-tests and not sensitizing the subjects

to testing, there was no interaction between the test given and the measured variable, so that generalization to a population of untested subjects could occur. However, logically, according to Campbell and Stanley (1970), generalization beyond the specific conditions of the experiment cannot be done, "i.e., we cannot generalize at all." (p. 17).

Sample and Selection

The subjects were professional registered nurses who were employed by a Veteran's Administration Hospital. Each registered nurse subject signed the Informed Consent Form. (See Appendix A) Using a table of random numbers, a random sample of forty-five registered nurses was selected from employment lists. Each registered nurse was then randomly assigned to the control group or to one of the two treatment groups so that each group had fifteen subjects. It was expected that the random sample would provide registered nurses of all ages, of both sexes, of different lengths of time since graduation from the basic nursing education program, of all types of educational programs, and of all lengths of time in practice. Each registered nurse chosen for the study was contacted by the researcher to enlist his/her participation.

Participants, those persons who had their blood pressure measured, were volunteers from an Associate Degree Nursing program. Nine volunteers participated after signing an Informed Consent Form. (See Appendix B) Participants were selected so that a variety of arm circumferences were included in the study. The range of arm circumference was 23.5 cm to 40 cm.

Two recorders made all of the observations of the blood pressure measurements without the researcher in the room. The recorders were

selected by the researcher for their attention to detail, their availability of time, their interest in research, and their nursing knowledge. One recorder was a registered nurse and a student in a master of nursing program. The other recorder was a licensed practical nurse and a student in an associate degree nursing program. The recorders directed the specific procedure, recorded the pertinent data, and assisted with record keeping.

Setting

The study took place at a Veteran's Administration Hospital. Quiet rooms were set up for the experiment in which there was space for the equipment and for all persons involved. The equipment was displayed on a table so that the manometer was closed and the three cuffs were easily seen. The manometer, the cuff, and the inflating bulb were required to be assembled. A stethoscope was also laying on the table. The participants were comfortably seated in a chair with a right side arm. Beside the chair was a high-low over-the-bed stand in low position. A comfortable straight chair was placed somewhat in front of the bed stand for the subject. The recorders directed the subjects and were free to view the procedure from the most advantageous position.

Data Collection

Instruments

The dependent variable was measured by a procedural check list. (See Appendix C) This check list was extrapolated from the text of the recommendations made by the AHA and written in measurable terms. The check list was arranged in the order in which each step of the procedure was likely to take place. Each item to be observed was given equal

importance, and there were a total of thirteen items which were measured as being either correct or incorrect. Nine of the items required only the watchfulness and judgement of the recorder, but four items required certain other measurements to be made. Items 1, 4, 12, and 13 required specific measurements and calculations.

Item 1 of the procedural check list required that an arm circumference measurement be made on each participant. Arm diameter was calculated after knowing the circumference. The proper size of the inflatable bag must be twenty per cent wider than the diameter of the arm (Kirkendall, et al., 1967). Since there were three sizes of inflatable bags, a chart was made which indicated the correct bag and cuff size for each arm size. (See Appendix F)

For Item 4 of the procedural check list, the recorder was required to estimate the distance between the cuff edge and the mid-antecubital space. The recorder was furnished with a centimeter ruler to assist with a comparison for a more accurate estimation. The subject was not interrupted to make the actual measurement.

In order to determine the correct response to Item 12, the recorder palpated the systolic pressure of the participant. The systolic pressure was determined by the pressure of the inflatable bag which was required to achieve the disappearance of the radial pulse. The recorder was then able to determine 30 mm Hg above the disappearance of the radial pulse. Thirty mm Hg $\pm$ 10 mm Hg above or below the disappearance of the radial pulse as calculated by the recorder was considered correct. This 10 mm range allowed for participant changes in blood pressure between the two measurements, as Mitchell and Van Meter (1971) used.

A stop watch was used to measure the deflation time for Item 13. In order to accurately calculate deflation time, the recorder wrote down the mm Hg to which the system was inflated by the subject and the mm Hg when the subject released the exhaust valve after the diastolic reading had been established. The stop watch was begun with the beginning of air release and stopped when the valve was opened completely. The mm Hg between the highest inflated pressure and the complete opening of the exhaust valve was divided by the number of seconds on the stop watch in order to calculate deflation rate.

Another instrument used was the questionnaire concerning demographic data. Information collected included: the type of basic education and post graduate education, the number of years since graduation from the basic education, the number of years in full time practice, and the present nursing position. Questions regarding the frequency of blood pressure measurements and if the subjects had participated in any review of blood pressure measurement procedures within the last year were also included. (See Appendix D)

A Mercury Baumanometer 300 Model was used for all blood pressure measurements. The sphygmomanometer was cleaned, checked, and calibrated by a competent employee of the hospital engineering staff. This maintenance was performed once before any measurements were made and again during the data collection to ensure that the instrument remained clean and calibrated. Three inflatable bag sizes were used. These sizes were 9 cm X 18 cm, 12 cm X 26 cm, and 15 cm X 33 cm. The cuffs were of conventional material with a velcro closure. The inflatable bags and cuffs

were new and had not been used prior to this study. A conventional stethoscope with a bell and a diaphragm was used for all blood pressure measurements.

Pilot Study

A pilot study was done to determine inter-rater reliability. The recorders first studied the Instructions for Recorders (See Appendix E) and the booklet, Recommendations for Human Blood Pressure Determination by Sphygmomanometers. After a practice session, five nurses were asked to measure blood pressure on five volunteers while the two recorders observed. The study conditions were followed. Neither the nurses nor the volunteers had any further connection with the study.

The number of errors for each of the thirteen items of the procedural check list was analyzed for each recorder. All nurses were scored the same on Items 1, 2, 5, 7, 9, and 13 by the two recorders. On Items 3, 6, 8, 10, 11, and 12, one recorder scored one error more or one error less than the other recorder. The largest scoring discrepancy between the two recorders was in the scoring of Item 4. Three nurses were scored as having made an error by one recorder while the second recorder scored all five nurses as having performed the step correctly.

One-way analysis of variance was calculated with $F\ (1, 24) = .01$, $p > .01$. The calculated $r^2 = .67$. Since scores for Item 4 showed such a discrepancy, a reliability measure was calculated with only twelve items, eliminating Item 4 from the test. The reliability measure without Item 4 gives $r^2 = .85$.

The pilot study demonstrated a need to further define a "correct" or "incorrect" behavior for several items, primarily Item 4. In Item 4, "checks", was defined by comparing ways in which the recorders could tell if the bag was completely deflated before it was inflated. If the subject a) squeezed the bag before placing it on the arm; b) placed the bag on the arm and the bag appeared uninflated to the recorder; and/or c) opened the exhaust valve anytime before closing it to begin inflation; then the procedure used for Item 4 was considered correct by the recorder.

Item 3 was redefined so that the step could be scored as being performed correctly if the subject was eye level with the manometer. The position of the subject, sitting or standing, was not considered since during the pilot study, some nurses did not sit down even though there was a chair provided; they leaned over to be eye level with the manometer. The difference in the scoring of Item 12 was the result of a difference in the palpated systolic pressure done by each recorder. The other items, Item 5, 8, 10, and 11, were discussed and clarified by the researcher.

Procedure

Once the subjects were identified and randomly assigned to the control group or to one of the treatment groups, they were tested in a sequential manner over a period of about four weeks. The control group was tested first, with the demonstration teaching group second and the booklet teaching group last. The teaching methods for the two treatment groups were not begun until all subjects of the previous group had finished the blood pressure measurement and were thus finished with

their part in the study. An intentional period of time was allowed between the demonstration teaching and the testing and between the giving of the booklet and the testing in order to allow for practice of the procedure or for reading the booklet, respectively. The mean number of days between the demonstration teaching and the time of the blood pressure measurement was 4.6 days. The booklet teaching group received the booklet a mean of 4.0 days before the blood pressure measurement was performed.

The researcher contacted each subject, explained the informed consent form, and enlisted the permission of the subject. At this first meeting, an appointment was made for the time that the blood pressure measurement would be performed, and, in the instance of the booklet teaching group, the booklet was given to those subjects. In the case of the demonstration teaching group, an additional appointment was made for the fifteen minute demonstration of blood pressure procedure.

Before the appointed time for each subject, the recorder set up the room and assisted the participant to put on a hospital gown with three-quarter length sleeves. The participant then sat quietly in a chair with a side arm for at least five minutes. In order to assess Item 1 of the check list, the arm circumference of the participant was measured at this time by the recorder. The recorder also palpated the systolic pressure of the participant using the radial pulse. The equipment was then disassembled and placed again on the table in preparation for the entrance of the subject.

After the recorder had prepared for the subject, the researcher brought the subject into the room. The researcher introduced the

subject to the recorder and to the participant and then left the room. The recorder asked the subject to choose the blood pressure equipment and to measure the blood pressure of the participant. The subject was given a 3 inch X 5 inch index card upon which to write the systolic and diastolic pressure readings. These recorded blood pressures were not used for any purpose other than to follow the procedure to the end. Only one measurement was made by each subject.

Once the blood pressure measurement was made, the subject was asked to complete the demographic questionnaire. That subject was then finished with the study and left the room. The recorder again assembled the equipment in readiness for the next subject to enter the room, and the procedure was repeated. If there were at least three consecutive subjects to perform measurements, the recorder palpated the systolic pressure of the participant after every third blood pressure measurement. At least five minutes were allowed between subjects.

Data Analysis

Inferential statistics were utilized to analyze the number of incorrect steps in procedures from the procedural check list. Since the measurements were interval scale and independent measures, and there were three groups, a single factor or one-way analysis of variance was calculated with a level of significance set at .05. Significance was found, and a Scheffe's F test was calculated to determine which difference was significant. A Kruskal-Wallis H test was also calculated and compared to the one-way analysis of variance.

Descriptive statistics were utilized in order to describe the sample population. Pictorial statistics, tables, and numerical statistics, percentages and averages, were used to describe the data from the various questions included in the demographic data questionnaire.

Summary

Following a pilot study, data were collected from three groups of professional registered nurses randomly selected and assigned. The control group was observed in the procedure of measuring blood pressure without any review teaching. The demonstration teaching group was instructed in the procedure as recommended by the AHA by a one-to-one fifteen minute demonstration by the researcher. This group was observed measuring blood pressure after the control group. The booklet teaching group was given the booklet, Recommendations for Human Blood Pressure Determination by Sphygmomanometers, to read. The booklet teaching group measured blood pressure after the demonstration teaching group. Thirteen items of the blood pressure procedure were measured as being performed correctly or incorrectly. A demographic questionnaire was also completed by each of the forty-five subjects. The incorrectly performed items were analyzed by inferential statistics, while the demographic data were analyzed by descriptive statistics. The blood pressure measurement data collection was diagramed as:

	Correct	Incorrect
Control Group A		
Demonstration Group B		
Booklet Group C		

CHAPTER III

RESULTS

Statistical analysis was completed on forty-five blood pressure measurements and on forty-five demographic questionnaires. Inferential statistics compared the three groups as to the number of errors which were made in the procedure of blood pressure measurement. There were three items of the procedure which showed no improvement as a result of either of the teaching methods. The remaining ten items of the procedure showed varying improvement or no improvement depending upon which teaching method was considered.

Blood Pressure Measurement

The number of errors and the standard deviation were computed for each of the three groups. The control group had a mean number of errors of 4.6 with a standard deviation of $\pm$ 1.8 errors. Group B had a mean number of errors of 1.6 with a standard deviation of $\pm$ 1.1, while Group C had a mean number of errors of 5.1 with a standard deviation of $\pm$ 1.5 errors (See Table 1). The ranges of the number of errors were 2 to 8 errors for the control group, 0 to 4 errors for Group B, and 2 to 8 errors for Group C.

TABLE 1

Mean Errors In Blood Pressure Measurement
For Control, Demonstration, and Booklet Groups

Group	N	$\bar{x}$ Errors	SD
Control	15	4.6	$\pm$ 1.8
Demonstration	15	1.6	$\pm$ 1.1
Booklet	15	5.1	$\pm$ 1.5

One-way analysis of variance (See Table 2) indicated a significant difference among the groups, F (2, 42) = 24.2, $p < .01$.

TABLE 2

Analysis of Variance of the Effects of Teaching Technique on the
Number of Errors in Blood Pressure Measurement

Source	SS	df	MS	F
Total	203.8	N-1=44		
Between	109.2	K-1=2	54.6	24.2**
Within	94.9	K(n-1)=42	2.26	

** = α .01

Kruskall-Wallis H test also indicated a significant difference, H (2) = 24.1, $p < .01$. Scheffé F test indicated a significant difference between the control group and Group B, the demonstration teaching group, F = 30, $p < .01$. There was no significant difference between the control group and Group C, the booklet teaching group, F = .83, $p > .05$. The first hypothesis was, therefore, accepted, and the second hypothesis was rejected.

An examination of the errors for each item of the procedure demonstrated which items were improved or not improved as a result of each teaching method. (See Table 3) Three subjects in the control group erred in Item 1 while there were no errors in the demonstration teaching group and eleven errors in the booklet teaching group. Item 2 was performed correctly by all forty-five subjects. Three errors were made in Item 3 by subjects in the control group with no errors in the demonstration teaching group and five errors in the booklet teaching group. No errors were made in Item 4. The control group subjects erred four times in Item 5 with two errors being made by each of the experimental groups. Item 6 was performed erronously by five subjects in the control group and in the booklet teaching group, with only one error being made by the demonstration teaching group. The same number of errors, fourteen, was made in Item 7 by both the control group and the booklet teaching group, with three errors in the demonstration teaching group. Item 8 was performed incorrectly by six subjects in the control group, one in the demonstration teaching group, and three in the booklet teaching group. Item 9 was performed incorrectly by only one subject in the demonstration teaching group with no errors made by subjects in either of the other two groups. One subject in the control group erred in performing Item 10 while no errors and three errors were committed by the subjects of the demonstration teaching group and the booklet teaching group, respectively. Four errors in Item 11 were made by the control group, while one error was made by the demonstration teaching group, and five errors were made by the booklet teaching group. The control group and the booklet teaching group both made fourteen errors in Item

12 with three errors being made by the demonstration teaching group. Item 13 was performed incorrectly by the most subjects with fifteen errors in the control and the booklet teaching groups and twelve errors in the demonstration teaching group.

TABLE 3

Errors in Blood Pressure Measurement by Item for the Control, Demonstration, and Booklet Groups

Item	Group A Control No.	Group B Demonstration No.	Group C Booklet No.
1	3	0	11
2	0	0	0
3	3	0	5
4	0	0	0
5	4	2	2
6	5	1	5
7	14	3	14
8	6	1	3
9	0	1	0
10	1	0	3
11	4	1	5
12	14	3	14
13	15	12	15
Total	69	24	87

Demographic Data

Descriptive statistics were computed on the data collected from the demographic questionnaires. The control group and the two treatment groups were characterized by basic educational preparation, years since graduation from basic nursing education, present position, years of full time practice, and number of blood pressure measurements made per day.

Educational Preparation

The three basic nursing education programs (i.e., the Associate Degree in Nursing [ADN], the Diploma in Nursing [DIP], and the Bachelor of Science in Nursing [BSN].) are represented in the sample, as shown in Table 4. Of the subjects in the control group 3 (20%) had an ADN, 8 (53%) had a DIP, and 4 (27%) had a BSN. Group B subjects showed a similar educational preparation with 4 (27%) having an ADN, 8 (53%) having a DIP, and 3 (20%) having a BSN. Five subjects (33%) in Group C had been prepared with an ADN, while 2 (13%) had a DIP and 8 (53%) had a BSN.

TABLE 4

Basic Nursing Education, Nursing Positions, and Number of Blood Pressure Measurements of the Control, Demonstration, and Booklet Groups

Characteristic	Group A Control		Group B Demonstration		Group C Booklet	
	No.	%	No.	%	No.	%
Basic Nursing Education						
ADN	3	20	4	27	5	33
DIP	8	53	8	53	2	13
BSN	4	27	3	20	8	53
Nursing Position						
Staff Nurse	10	67	12	80	11	73
Head Nurse	5	33	1	6	1	6
Administrator			1	6		
Other			1	6	3	20
Number of Blood Pressure Measurements Per Day						
Often (10-15)	3	20	2	13	4	27
Seldom (5-9)	9	60	6	40	3	20
Never (0-4)	3	20	7	47	8	53

In the control group there was one subject who had a bachelor of science degree in another field. All other subjects in the control group had no degrees beyond the basic nursing education. Group B had three subjects with a bachelor of science or arts degree in other fields and one subject with a Master of Nursing. Similarily, Group C also had one subject with a Master in Nursing, while one subject had a master's degree

in another field. The control group and the two treatment groups were similar in further educational preparation of the subjects. Group C was higher in ADN and BSN preparation and lower in DIP preparation than either of the other groups.

Years Since Graduation

Table 5 shows the mean years and the standard deviation since graduation from the basic nursing education program. Subjects in the control group have a total of 282.5 years since graduation from the basic nursing education with a range from one year to 37 years. The mean number of years since graduation was 18.3 years with a standard deviation of $\pm$ 13.3 years. The subjects in Group B had a total of 247.5 years since graduation from the basic nursing education with a range from one to 35 years. The mean number of years since graduation was 16.5 years with a standard deviation of $\pm$ 12.8 years. A total of 122.7 years since graduation was accumulated by Group C. The mean number of years since graduation was 8.2 years with a standard deviation of $\pm$ 6.3 years. The range was from two months to 20 years. One-way analysis of variance indicated no significant difference in the years since graduation, F (2,42) = 3.59, $p > .01$.

TABLE 5

Mean Years Since Graduation and Full Time Practice for the Control, Demonstration, and Booklet Groups

Variable	Group A* Control $\bar{x}$ years	SD	Group B* Demonstration $\bar{x}$ years	SD	Group C* Booklet $\bar{x}$ years	SD
Graduation from Basic Nursing Education	18.3	±13.8	16.5	±12.8	8.2	±6.3
Full Time Practice	16.6	±11.6	11.0	±10.4	7.3	±5.7

*N = 15

Present Position

The positions included on the demographic questionnaire were staff nurse, head nurse, administrator, inservice educator, and other. The specifics are given in Table 4. Of the control group, 10 (67%) were staff nurses and 5 (33%) were head nurses. In Group B there were 12 (80%) staff nurses, one (6%) head nurse, one (6%) administrator, and one (6%) supervisor (specified in the "other" category). Group C consisted of 11 (73%) staff nurses, one (6%) head nurse, and 3 in the "other" category, specified as one supervisor, one nurse practitioner, and one infection control nurse. The three groups compare favorably in the positions in nursing.

Years of Full Time Practice

The subjects in the control group had a total of 248.5 years in full time nursing practice with a range from one to 32 years. (See Table 5). The mean number of years of full time practice was 16.6 with

a standard deviation of ± 11.6 years. The range for Group B was 4 months to 35 years with a total of 165 years of full time practice. The mean number of years of full time practice was 11 years with a standard deviation of ± 10.4 years. Group C logged a total of 109.7 years of full time practice with a mean number of years of 7.3 and a standard deviation of ± 5.7 years. The range was 3 months to 20 years. One-way analysis of variance indicated no significant difference among the groups in years of full time practice, F (2,24) = 3.55, $p > .01$.

Blood Pressure Measurements Per Day

Table 5 gives the number of times per day the professional registered nurse in the sample measured blood pressure. The choices on the questionnaire were often (10-15), seldom (5-9), and never (0-4). The control group had 3 (20%) nurses who took blood pressure often, while 9 (60%) and 3 (20%) took blood pressure seldom or never, respectively. Group B had 2 (13%) nurses taking blood pressure often, 6 (40%) nurses taking blood pressure seldom, and 7 (47%) nurses taking blood pressure never. The breakdown for Group C included 4(27%) nurses who took blood pressure often, 3 (20%) seldom, and 8 (53%) never. For all subjects, 36 or 80% take blood pressure less than nine times per day while one 9 or 20% take blood pressure ten or more times per day.

Inservice Review of Blood Pressure Procedure

Forty-three of the forty-five subjects had had no inservice review on the procedure of measuring blood pressure since their basic nursing preparation. Of the two subjects who answered positively to the question, one had read a magazine article on blood pressure and the

second was a "hypertensive specialist" on the ward. This second subject, however, gave no specifics on the type of review received.

CHAPTER IV

DISCUSSION

General

Two salient factors in the present study were that: a) Nurses do make errors in the procedure of blood pressure measurement when compared to the AHA recommendations; and b) With a demonstration of the AHA procedure, significantly fewer errors are made. It is, therefore, important to examine in which steps of the procedure the demonstration teaching was most effective, and if the booklet teaching was effective for any change in procedure. This examination can be accomplished by comparing the three groups in regard to the total number of errors made in each item. For clarity the items have been categorized into two sections; those showing no improvement, and those showing improvement. A brief discussion of data gathered from the demographic questionnaire is included, when that data can be compared to the same information in other studies.

Items Showing No Improvement

Item 2, placing the mercury manometer vertically, and Item 4, checking to see that the inflatable bag was deflated before wrapping the cuff, were performed correctly by all forty-five subjects. In the case of Item 2, the manometer used had only two positions, horizontal or vertical, and all subjects placed the sphygmomanometer on the high-low over-the-bed stand which was level. With the broad definition of the word, "checks", in Item 4, all subjects demonstrated at least one of the three behaviors which was correct. Essentially, then, no errors could be made on either Item 2 or Item 4.

For Item 9, placing the stethoscope over the brachial artery, all subjects in the control group and in Group C performed the step correctly. One subject in Group B placed the stethoscope on the lateral side of the antecubital space instead of the medial side over the brachial artery, which was considered incorrect. No improvement was, therefore, shown in these three steps of the procedure.

Items Showing Improvement

Item 10, leaves no space between diaphragm of stethoscope and patient's skin, showed the lowest number of error differences between the control group and Group B. One subject in the control group erred and left space between the diaphragm of the stethoscope and the skin, while all subjects in Group B held the diaphragm completely against the skin. Group C showed the most errors of the three groups in Item 10 with three subjects erring. An error in the firm placement of the stethoscope may result in extraneous environmental noises (Lancour, 1976) interferring with the ascultatory sounds of Korotkoff and thus in the final determination of the systolic and diastolic readings. Too great a pressure in the placement of the stethoscope can result in the decrease of arterial blood flow and can also produce extraneous sounds. (Stephens, 1966).

Item 5, centering the inflatable bag over the inner aspects of the arm, showed improvement in both Group B and Group C. Four subjects in the control group erred in this procedure while only two erred in each of the treatment groups. Measurement errors can occur as a result of the inflatable bag being improperly positioned (Karvonen, et al., 1964; King, 1969; Simpson, et al., 1965; and Steinfeld, et al., 1974).

Four items showed an improvement by three fewer errors in Group B over the control group. These items were 1, chooses the proper sized inflatable bag for patient's arm size; 3, sits so that mercury manometer is at eye level; 11, places stethoscope so that it does not touch clothing or cuff edge; and 13, releases the pressure in the inflated cuff at a rate of 2-3 mm Hg per second. All subjects in Group B chose the correct inflatable bag and cuff size while three subjects from the control group chose incorrect sizes. It is interesting to note that in Group C, eleven of the fifteen subjects chose an incorrect size of inflatable bag and cuff. The outcome for this item may be spurious, however, since four of the measurements of Group C were made on arms which were correctly sized for the adult bag, 12 cm X 26 cm, the most common size. Three measurements of Group C required the larger bag size, 15 cm X 33 cm, and eight measurements required the smaller bag size, 9 cm X 18 cm. Of the measurements made by the control group, three required the largest bag size and two of the three errors were made by subjects who chose the 12 cm X 26 cm bag, rather than the 15 cm X 33 cm bag. The remaining measurements required the bag measuring 12 cm X 26 cm. All arm circumferences of the participants in Group B measurements were correctly sized for the 12 cm X 26 cm bag and cuff.

There were no errors made by Group B in being at eye level with the manometer, Item 3, as compared to the three errors made in the control group. Five subjects erred in the procedure for this item from Group C, however, so that information was not gained by reading the booklet, or the information, once gained, was not followed. If the

objective had been closely followed, i.e., if sitting only, rather than sitting and standing, had been closely followed, there might have been more errors for subjects in all groups, since nurses do not seem to sit down but lean over in order to be eye level with the manometer.

Four subjects in the control group and five subjects in Group C erred in Item 11 by having the stethoscope touching either clothing or the cuff. Only one subject erred in Group B, thus showing improvement. It is common to see nurses place the stethoscope under the cuff, supposedly to hold the stethoscope in place, but uneven pressure is applied to the arm when the stethoscope is placed under the cuff and can give distorted readings (Lancour, 1976). Gunn, et al. (1966), however, incorporated into their study, stethoscopes both under the cuff and in the antecubital space not touching the cuff, and found no significant difference in either the systolic or diastolic readings.

Group B showed very little improvement over either the control group or Group C in correct deflation rate. All fifteen subjects in the control group and in Group C erred in the rate for deflating the bag. In Group B twelve subjects erred. In order to better understand the errors made in Item 13, mean deflation rate for each group must be examined. The control group had a mean deflation rate of 7.3 mm Hg per second. Group B showed a slower mean deflation rate of 4.9 mm Hg per second, but still too fast to be considered correct. The deflation rate for Group C was similar to the control group, with a mean of 6.8 mm Hg per second. Glor's study (1966) suggests that the rate of deflation may be the most crucial factor in controlling observer errors. The present study certainly points out that even with specific

instruction and demonstration, nurses continue to deflate the bag too quickly, thus throwing considerable doubt upon the reliability of blood pressure measurements. When the mercury drops in the manometer too quickly, other observer error factors such as mental concentration and reaction time, confusion of auditory and visual cues, and reading a moving column (Rose, et al., 1964) are effected and may multiply the error factor. Perhaps the most important error factor when considering the deflation rate is an aspect of the construction of the mercury manometer. The upper end of the manometer is fitted with a porous disc, a kidskin diaphragm in the case of the Baumanometer in this study (Baumanometer Service Manual, 1973, p. 9). This kidskin diaphragm is held in place by a chrome cap at the top of the open glass tube, and its purpose is to prevent the mercury from escaping when the manometer is folded into the case during transporting. Since blood pressure measurement yields a pressure value which is the difference between intra-arterial pressure and atmospheric pressure, it is imperative for an accurate reading that the pressure on the mercury in the glass tube remain at atmospheric pressure. The porous diaphragm allows air to pass into the glass tube as the mercury column falls during a blood pressure measurement. If the mercury falls too rapidly, however, the porous diaphragm interferes with the inflow of air into the glass tube so that the pressure on the mercury column drops below atmospheric pressure. The result is an erroneously high arterial pressure reading.

Five subjects in the control group and five subjects in Group C did not wrap the cuff at least 2.5 cm above the antecubital space, Item 6. Only one subject in Group B erred in this step of the procedure.

The outcome of Item 6 directly related to Item 11, and the results in the number of subjects erring are similar. If one does not properly place the cuff above the antecubital space, then there is the likelihood of touching the stethoscope to the edge of the cuff.

It was found that six subjects in the control group did not perform Item 8 correctly, i.e., they did not palpate the brachial artery pulse. One subject in Group B and three subjects in Group C did not correctly perform this step. It can be surmized that the subjects not palpating the brachial artery pulse made an assumption of the anatomical position of the brachial artery and thus, assumed the position for the placement of the stethoscope. It is obvious that if these assumptions of the position of the brachial artery are incorrect, then the Korotkoff sounds could not be heard at their maximum intensity, and the reliability of the interpretation for systolic and diastolic pressures would be greatly reduced.

The greatest source of improvement as the result of the demonstration teaching was demonstrated in Items 7 and 12. Both the control group and Group C had fourteen subjects who made errors in each of these items. For Item 7, palpating the radial artery for the systolic pressure, only three subjects erred in Group B. Three subjects erred in Group B also in the performance of Item 12, inflating the bag to 30 mm Hg above the palpated systolic pressure. Since these two items are inter-related, the outcome was expected to be similar.

Demographic Data

Age was not considered in this study, but years since graduation was considered. If age in other studies (Glor, 1966; Glor, et al., 1970)

has been considered as a measurement of competence or educational milieu (as it might have been in this study), then years since graduation from the basic educational program is a more reliable measurement today. Persons are entering basic nursing programs at a later age and in some cases, after completing other basic education first. For that reason, the present study looked at years since graduation, and thus, has no comparison to make with other studies.

Both Blor (1966) and Glor, et al., (1970) gathered data concerning years of practice in nursing and found that the average professional nurse in their studies had been in practice ten and one-half years and thirteen years, respectively. When the mean years for full time practice for all forty-five subjects for the present study was calculated, the mean of 11.6 years of full time practice compares favorably with the other two studies.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study has undertaken to approach the problem of variability in blood pressure measurement by examining the procedural aspect of that measurement as it is performed by professional registered nurses. Control of the variables of true variation and measurement errors of the instrument allowed for a controlled study of measurement errors of the observer by studying the procedure of blood pressure measurement. This study examines the nursing practice of blood pressure measurement.

That following a standardized procedure for blood pressure measurement increases the reliability of a blood pressure reading is not disputed. The present study shows that the AHA standards are not closely followed by professional registered nurses, as Mitchell and Van Meter (1971) concluded. Likewise, by giving out the booklet, Recommendations for Human Blood Pressure Determination by Sphygmomanometers, by the AHA, registered nurses did not change their procedure. If a demonstration of the AHA recommendations is given to nurses, however, the procedure which the nurse uses was significantly changed. This change in the procedure of measuring blood pressure may result in more reliable blood pressure measurements. It is known that by following a standardized procedure, blood pressure measurements are reproducible (Bender, 1970) and not significantly different between observers (Glor, 1966; Glor, et al., 1970; Gunn, et al., 1966). This study demonstrates that nurses can and will follow the AHA standards for the procedure of measuring blood pressure when a demonstration teaching method is used. The change in the nursing practice of the measurement can increase the reliability of

blood pressure readings.

Conclusions

The first hypothesis, that there would be a significant difference in the number of errors made by the control group when compared to the demonstration teaching group, Group B, was accepted, F (2, 42) = 24.2, $p < .01$, and $F = 30$, $p < .01$.

The second hypothesis, that there would be a significant difference in the number of errors made by the control group when compared to the booklet teaching group, Group C, was rejected, $F = .83$, $p > .05$.

Recommendations

It is recommended that a number of studies be carried out as a result of this study. These recommendations will be limited to include further research directly related to the procedure of blood pressure measurement. These may include:

1. Replication of this study using a different population of professional registered nurses.
2. Replication of this study using a population including other health care personnel such as licensed practical nurses and nursing assistants.
3. Follow-up study on the subjects used in this study to measure retention of information and continued adherence to the AHA recommendations.

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APPENDICES

APPENDIX A

INFORMED CONSENT FORM

I, _____, agree to serve as a subject in the clinical investigation of Jean Taylor, R.N., B.S.N., titled, "The Measurement of Blood Pressure by Registered Nurses", under the supervision of Marie Berger, R.N., M.S.

I understand that my part in the investigation will be to measure and record systolic and diastolic blood pressure readings on a volunteer participant and to answer certain questions related to my position and education as a registered nurse. I understand that my part will require about thirty (30) minutes. There is no risk for me in this procedure. All information will be kept confidential, and I will not be identified by name but only by a code number.

Jean Taylor has offered to answer any questions I might have regarding my participation in the study. I understand I am free to refuse to participate at any time if I so desire.

I have read the foregoing and agree to participate in this study.

Date_____ Subject_____

Witness_____

APPENDIX B

INFORMED CONSENT FORM

I, _____, agree to participate as a participant in the clinical investigation of Jean Taylor, R.N., B.S.N., titled "The Measurement of Blood Pressure by Registered Nurses", under the supervision of Marie Berger, R.N., M.S.

I understand that I will be having my blood pressure measured by several registered nurses and that I will spend between one and two hours. There is no risk to me from this procedure. All information will be kept confidential, and I will not be identified by name but only by a code number.

Jean Taylor has offered to answer any questions I might have regarding my participation in the study. I understand I am free to refuse to participate at any time if I so desire.

I have read the foregoing and agree to participate in this study.

Date_____ Participant_____

Witness_____

APPENDIX C

PROCEDURAL CHECK LIST -- DATA COLLECTION

	Yes	No
1. Chooses the proper sized inflatable bag for patient's arm size.		
2. Places mercury manometer in a vertical position.		
3. Sits so that mercury manometer is at eye level.		
4. Checks to make sure the inflatable bag is deflated before wrapping the cuff.		
5. Centers the inflatable bag over the inner aspect of the upper arm.		
6. Wraps the cuff with a margin of at least 2.5 cm between lower edge of cuff and patient's antecubital space.		
7. Palpates radial artery for systolic pressure in order to determine maximal pressure to which the system needs to be elevated. (Radial arterial pulse disappearance)		
8. Palpates brachial artery pulse.		
9. Places stethoscope over brachial artery in antecubital space.		
10. Leaves no space between diaphragm of stethoscope and patient's skin.		
11. Places stethoscope so that it does not touch clothing or cuff edge.		
12. Inflates bag to 30 mm Hg $\pm$ 10 mm Hg above the palpated disappearance of the radial pulse.		
13. Releases the pressure in the inflated cuff at a rate of 2-3 mm Hg per second.		

APPENDIX D

DEMOGRAPHIC DATA -- DATA COLLECTION

1. Identification number_____
2. Type of Basic Nursing Education:
   _____Associate Degree
   _____Diploma
   _____Bachelor of Science
3. Years since graduation from Basic Nursing Education_____
4. Highest Degree Held:
   _____B.S. in Nursing
   _____B.S. or B.A. in other field
   _____Master's Degree in Nursing
   _____Master's Degree in other field
   _____Other
5. Years since graduation from #4 above_____
6. Years of Full Time Practice_____
7. Years of Part Time Practice_____
   Please specify number of days per week, if part time practice_____
8. Present Position:
   _____Staff Nurse
   _____Head Nurse
   _____Administrator
   _____Inservice Educator
   _____Other, please specify_____
9. Using the following categories, estimate the number of times per day that you measure and record blood pressures:

_____Often	_____Seldom	_____Never
(10-15)	(5-9)	(0-4)

10. Have you received any inservice review of the procedure for measuring blood pressure within the last year?
    _____Yes _____No
    If yes, what was the manner of the review?_____
    _____

APPENDIX E

INSTRUCTIONS FOR RECORDERS

Your responsibility as a recorder in the present research includes introducing the subject and the participant, giving instructions to the subject, and measuring the procedure used by the subject. What follows is a set of instructions to be followed for each of these three responsibilities.

1. Participant Preparation
   - A. Give participant a gown to wear.
   - B. Assist the participant to be comfortably sitting in a chair with the arm at the height of the heart.
   - C. Measure the arm circumference of the participant.
   - D. Determine and record the systolic blood pressure by palpatory method.
2. Subject Preparation
   - A. Introduce self and the participant to the subject.
   - B. Instruct subject to obtain stethoscope and to obtain sphygmomanometer with cuff size which is deemed by subject as most appropriate size for participant.
3. Procedural Check List
   - A. Objectives number 2, 3, 4, 6, 7, 8, 9, 10, and 11 are to be observed, judged, and recorded in one of the two columns.
   - B. Objective number 1: Record the size of the cuff subject uses, then calculate from the arm circumference and the cuff size chart.

C. Objective number 5: Estimate the 2.5 cm distance using the centimeter ruler to better evaluate your estimate.

D. Objective number 12: Record highest pressure to which subject inflates bag, then calculate from systolic pressure measured by palpation by you.

E. Objective number 13: Use stop watch provided to time deflation rate and record. Divide mm Hg to which bag has been inflated by the number of seconds of the deflation time.

APPENDIX F

Correct Bag Sized by Arm Circumference for Each Participant

Participant	Arm Circ. cm	Necessary Bag Width cm	Correct Bag Size cm
1	40	15.3	15 X 33
2	33	12.6	15 X 33
3	31.5	12.0	12 X 23
4	30.5	11.7	12 X 23
5	29	11.7	12 X 23
6	26.5	10.1	12 X 23
7	26	9.9	12 X 23
8	24	9.2	12 X 23
9	23.5	9.0	9 X 18

APPENDIX G

Raw Data
Control Group A

Subject	No. Errors in Blood Pressure Measurement	Basic Educational Preparation	Years Since Graduation	Present Position	Years Full Time Practice	Blood Pressure Measurements Per Day
1	7	BSN	29	Head Nurse	29	Seldom
2	6	BSN	7	Head Nurse	7	Seldom
3	8	DIP	21	Staff	21	Never
4	4	BSN	3	Head Nurse	3	Never
5	5	ADN	1	Staff	1	Never
6	4	ADN	3	Staff	3	Seldom
7	3	DIP	37	Staff	27	Seldom
8	2	BSN	1.5	Staff	1.5	Seldom
9	6	DIP	26	Staff	26	Seldom
10	2	DIP	32	Head Nurse	32	Seldom
11	3	DIP	31	Staff	20	Seldom
12	4	DIP	35	Staff	30	Often
13	4	DIP	33	Staff	25	Seldom
14	4	DIP	14	Head Nurse	14	Often
15	7	ADN	9	Staff	9	Often

Raw Data
Demonstration Group B

Subject	No. Errors in Blood Pressure Measurement	Basic Educational Preparation	Years Since Graduation	Present Position	Years Full Time Practice	Blood Pressure Measurements Per Day
1	0	BSN	1	Staff	1	Never
2	1	DIP	35	Staff	35	Never
3	3	BSN	15	Staff	4	Often
4	2	BSN	5	Staff	4	Never
5	1	DIP	11	Other	11	Never
6	2	ADN	1.5	Staff	.6	Seldom
7	1	DIP	28	Staff	20	Seldom
8	0	DIP	32	Staff	16	Never
9	1	DIP	14	Staff	14	Often
10	1	DIP	15	Administrator	11	Seldom
11	4	ADN	1	Staff	3.4	Seldom
12	4	DIP	22	Staff	9	Never
13	2	DIP	33	Head Nurse	7	Never
14	2	ADN	3	Staff	3	Seldom
15	1	ADN	31	Staff	29	Seldom

Raw Data
Booklet Group C

Subject	No. Errors in Blood Pressure Measurement	Basic Educational Preparation	Years Since Graduation	Present Position	Years Full Time Practice	Blood Pressure Measurements Per Day
1	5	ADN	6	Staff	6	Often
2	6	ADN	5	Staff	5	Often
3	8	ADN	7	Staff	7	Often
4	4	DIP	20	Staff	20	Seldom
5	6	BSN	19	Head Nurse	17	Never
6	6	BSN	.2	Staff	.2	Never
7	6	BSN	4	Staff	4	Never
8	7	BSN	7	Staff	7	Never
9	5	ADN	2.5	Staff	2.5	Seldom
10	5	BSN	3	Other	3	Never
11	5	ADN	6	Staff	6	Often
12	4	DIP	15	Other	5	Never
13	4	BSN	15	Other	14	Never
14	4	BSN	11	Staff	11	Never
15	2	BSN	.2	Staff	2	Seldom

AN ABSTRACT OF THE CLINICAL INVESTIGATION OF

JEAN ANN TAYLOR

For the: MASTER OF NURSING

Date of receiving this degree: June 8, 1979

Title: THE MEASUREMENT OF BLOOD PRESSURE BY REGISTERED NURSES

Approved: _____

Marie Berger, M.S., Associate Professor, Advisor

The purpose of this study was to determine if registered nurses follow the American Heart Association's (AHA) recommendations for blood pressure measurement by sphygmomanometers and to determine if, given either a demonstration of the recommended procedure or given the booklet, Recommendations for Human Blood Pressure Determination by Sphygmomanometers, registered nurses change their practice for measuring blood pressure. A post-test control group design was utilized with a control group and two treatment groups. One treatment group received the teaching method of an individual demonstration of the recommendations of the AHA. The second treatment group received the teaching method of reading the AHA's booklet which was given to them. Each of the three groups comprised fifteen professional registered nurses randomly selected from employment lists of a Veteran's Administration Hospital.

The dependent variable was measured by a procedural check list extrapolated from the AHA recommendations and written in measurable terms. A demographic questionnaire was used to collect data regarding the type of basic nursing education, the number of years since graduation from basic education, the number of years of full time practice, the present position in nursing, and the number of blood pressure measure-

ments performed per day.

One-way analysis of variance was computed on the number of errors made in each group. This statistic indicated a significant difference among the three groups, F (2, 42) = 24.2, $p < .01$. Scheffé F test indicated a significant difference between the control group and the demonstration teaching group, F = 30, $p < .01$. No significant difference was found between the control group and the booklet teaching group, F = .83, $p > .05$.